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Mixed bag: Simulating market-based instruments for water quality and quantity in the Upper Waikato

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Summary and Key Words

We designed and implemented participatory computer simulations in three workshops in New Zealand's Upper Waikato catchment to learn how market-based instruments (MBIs) might improve freshwater outcomes when managing water and land resources within limits.

An Excel-based platform was built to simulate, in stakeholder workshops, the use of transferable permits and user charges for both water quantity and water quality in the Upper Waikato catchment. Each participant managed a hypothetical property in a simplified catchment that included seven farms, a pulp mill, district council, and a hydro-electric company. Based on profit schedules and policy settings, participants made choices about production intensity, land use change and trading of water and/or nutrient allowances.

The simulations highlighted the social and cultural context in which MBIs must operate, and how that context influences the outcomes that we can expect from MBIs. Participants found the simulations to be a valuable learning experience.

Key words: simulation, water trading, discharge trading, water quality, market-based instruments

1. Introduction

Market-based instruments (MBIs), sometimes referred to as economic instruments, refer to policies that use markets or other financial incentives to achieve desired outcomes, and include a wide variety of possible measures – see Box 1. These include policies that create new markets for environmental goods and services, taxes and charges on resource use and pollution, policies requiring that adverse effects be offset or otherwise mitigated, and liability for damage to the environment.

There is a substantial literature, both theoretical and applied, on the potential and actual use of MBIs, including in freshwater management (see e.g. Breetz et al., 2005; Fenemor and Sinner, 2005; Fenemor, 2007; Grafton et al., 2011; Greenhalgh and Selman, 2011a;

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Greenhalgh and Selman, 2011b; Kerr and Lock, 2009; MacDonald et al., 2004; PCE, 2006; Robb et al., 2001; Schelling, 1983; Selman et al., 2009; Shortle, 2012; Sinner and Salmon, 2003; Sinner et al., 2005; Tisdell, 2011; UNEP, 2004). Sinner and Salmon (2003) noted a lack of clarity in the RMA and Local Government Act regarding the use of MBIs, especially those that involve charges; this situation is largely unchanged.

The Government's Fresh Start for Fresh Water (FSFW) envisages that a broad toolkit is needed to improve water management in New Zealand, potentially including MBIs operating within a well-designed regulatory framework. This paper examines how transferable (or tradeable) permits and water charges could be designed for inclusion within Resource Management Act policy to deliver those improved water management outcomes.

2. Methodology

We used participatory computer simulations in six stakeholder workshops, plus interviews with participants and water sector stakeholders, to learn how appropriately designed market-based instruments might improve outcomes when managing catchment water and land resources within limits. Two Excel-based simulation platforms were built. The first case simulated water allocation in a notional Hawke's Bay catchment. The second simulated MBIs for water quantity and water quality together, for a case study in the Upper Waikato catchment. This paper reports on the Upper Waikato case study only.

Box 1: Types of Market-Based Instrument

Market-creation techniques

- Tradeable emission permits
- Tradeable development rights
- Tradeable water allowances
- Individual transferable fishing quota

Prices, taxes and charges

- Differential pricing
- Emission charges and discharge fees
- Differential tax treatment
- User fees
- Financial contributions

Compensation mechanisms

- Offsets
- Mitigation banks

Liability mechanisms

- Deposit-refund schemes
- Performance bonds
- Mandatory insurance
- Legal liability for damage

For the simulations, each participant was assigned an enterprise (irrigated or dryland farm, industrial water user, council water supplier, or hydro-electric operator). Based on profit schedules relating enterprise operations with water use – and in the Waikato case, nutrient losses – and based on policy and weather settings for that scenario, each participant made choices about land use change and buying or selling water and/or nutrient allowances. At the end of each round the individual and catchment outcomes of those decisions were reported: allowance allocations, land use, water use, nutrient use, river condition, profit, trading volumes and prices.

Data derived from the simulations were complemented with results of discussions with participants about their attitudes and understanding of MBIs and reasons for their decisions in each simulation. Pre- and post-workshop interviews were completed, as well as interviews with additional tangata whenua, farmer groups and regional council staff. Because the simulations are a simplification of reality, with less uncertainty and with decision-making geared towards profit maximisation, the discussion and interviews provided a broader canvas for evaluation of transferable permits and water charging.

3. The simulated catchment

For purposes of simulating policy scenarios, we developed a simplified model of the Upper Waikato as shown in Figure 1, with two hydro lakes and their catchments. The simulations included limits on abstractions and on nitrogen and phosphorus discharges (both point and diffuse sources) for Catchment 1 and limits for combined abstractions and discharges in Catchments 1 and 2.

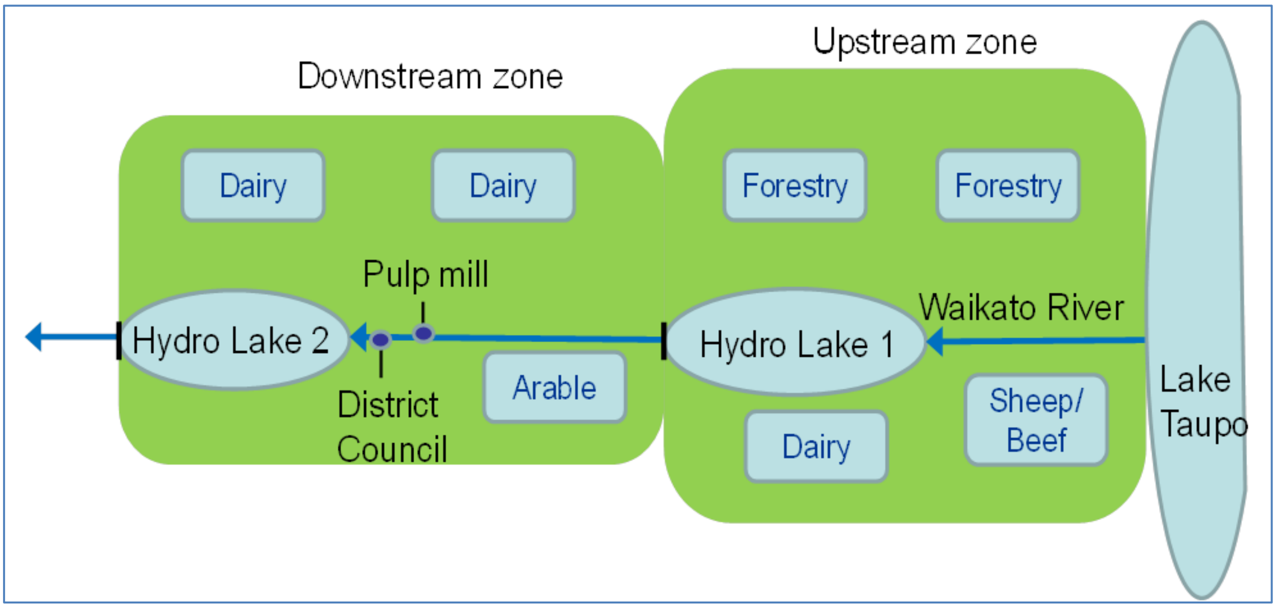

Figure 1. A simplified model of the Upper Waikato, with two hydro lakes and their catchments, used for simulations.

Because point sources (a pulp and paper mill and Tokoroa municipality) are important sources of both nitrogen and phosphorus inputs to the Waikato River, we included both of these entities in the simulations. Similarly, the hydroelectric dams are a major feature of the Upper Waikato. Water abstracted from the river or its tributaries reduces the amount that flows through the turbines in a series of power stations. The simulations included an entity with two power stations, one in each catchment. The Appendix provides a brief description of each of the enterprises in the simulations.

4. Simulation scenarios and participants

We implemented a number of policy scenarios during the course of three workshops. Some scenarios were one round only while others included two or more connected rounds where the results of one round determined the starting point for the next.

All of the scenarios had the following basic features:

- Both flow (Q) and nutrient (either N or P) limits for each lake catchment as described above; Q is assumed to be fully allocated.
- Initial allocations of both N and Q based on ‘grandparenting’.
- Downstream transfers of Q and N (or P) permitted between all uses and discharges; upstream transfers require approval.
- The hydro operator is assigned explicit, transferable allowances for a portion of the flow, and allowed to buy or sell water allowances to adjust flow through the two dams.
- Changes of land use incur an annualised conversion cost.
- Trades are pair-wise and via open-call market and must be recorded by simulation manager before they take effect.
- No banking of Q or nutrients (i.e. no carry forward of unused allocations to following round).
- Compliance is ex ante, i.e. a participant is not allowed to complete a round unless they have sufficient permits for their land use selections.

Participants were recruited from within the Waikato catchment and involved farmers (dairy and other), staff from a hydroelectric company and a pulp and paper mill, members of local Māori organisations and staff from the regional council. Attendance varied; some attended all three while others attended only one or two sessions. Members of the project team managed properties when there were insufficient stakeholders for all ten properties. Each workshop lasted about three hours plus a break for an evening meal.

5. The first workshop: Upper Waikato #1

5.1. Workshop scenarios and outcomes

After familiarising participants with the computer spreadsheets for their properties, the first workshop explored gains from trade in permits to take water (‘water permits’), how this changed with a cap on nutrient losses from each property, and then how participants managed when both water and nutrient permits were tradeable. Most of the seven rounds included constraints on how much water and nutrients could be transferred upstream from the downstream catchment, to avoid unacceptable effects on upstream river condition.

Based on economic theory, we expected that reducing the availability of water or nutrients would reduce financial returns and that trading would result in increased financial returns, all else equal. Constraints on trade (e.g. preventing upstream transfers) were expected to reduce returns compared to no constraints on trade.

Table 1 presents the simulation results. In Round 2, as expected, allowing trading of water permits enabled a significant increase in financial returns ($24,650 compared to $20,900 in Round 1) as entities with surplus water sold allowances to others. This came at the expense of water quality as allowances that were unused in Round 1 could now be exercised. The next round repeated this scenario but involved a limit on water (quantity) allowances that could be transferred upstream, as one way of trying to protect water quality. While nutrient discharges were reduced compared to Round 2, with some financial cost (as expected), the reductions were insufficient to achieve the 'good' river condition built into the simulation design.

Round 5 introduced nutrient regulation, with no trading of either water or discharge allowances. Phosphorus (P) discharges were capped at a level that would ensure that 'Good' river condition was achieved. Some entities received an allocation of P units that required a reduction in land use intensity or, in the case of the district council and pulp mill, investment in mitigation options. Financial returns fell to $18,750.

In Round 6, trading of P was allowed and in Round 7, water trading was reintroduced, in both cases with limits on upstream trading. As expected, financial returns increased (to $19,200 in Round 6 and $19,900 in Round 7).

Round 9 repeated Round 7 but with the limit on upstream trading removed. We expected this to result in greater financial returns and reduced river condition in the upstream zone, but this did not occur. Both participants managing upstream forestry properties decided to stay in forestry rather than convert to pastoral farming – one commented later that it was difficult and costly to acquire enough P units.

5.2. Observations from Upper Waikato #1

Water users are not accustomed to calculating the marginal value of a unit of water or nutrient discharge. Even though the simulations had quite simple profit schedules, people made mistakes, especially when water and P were both constrained and tradeable. Participant comments included:

> *Bought too much water – couldn't resell extra, couldn't store and wait for market.*
>
> *Sloppy paperwork & market entry very confusing; can lead to costly mistakes.*

Table 1: Results from Upper Waikato #1. (Takes and discharges for the Lower River include those in the Upper River; some rounds were skipped due to time constraints)

Results - Waikato #1	**Round 1**	**Round 2**	**Round 4**	**Round 5**	**Round 6**	**Round 7**	**Round 9**
	Business As Usual	**Sleeper Permits (1)**	**Constrained Trade**	**Nutrient regulation**	**Gains from Trading P**	**Gains: Water & P**	**Unconstrained Trading**
	Water limits only. Some farms with surplus. No trading.	Trading allowed.	Trading allowed, upstream transfers limited.	P limited to "good practice". No trading of water or P.	Trading of P but not water. Upstream limit.	Trading of P & water. Upstream limit.	Trading of P and water. **No** upstream limit.
River Quality	*Upper Rive*	*Upper Rive*	*Upper Rive*	*Upper Rive*	*Upper Rive*	*Upper Rive*	*Upper Rivei*
Total takes	3	9	7	2	3	7	5
P discharges	3.7	5	4.4	2.5	3.3	3.4	3
River condition	Good	Fair	Fair	Good	Good	Good	Good
	Lower River	*Lower River*	*Lower River*	*Lower River*	*Lower River*	*Lower River*	*Lower River*
Total takes	20	27	24	17	17	21	19
P discharges	10.1	12.3	11.8	8.1	8.4	8.4	8.5
River condition	Fair	Poor	Poor	Good	Good	Good	Good
Financial outcomes							
Total profit: farming	15100	17650	17050	13200	14150	14600	13850
Non-farm entities	5800	7000	6850	5550	5050	5300	4850
Overall outcome	20900	24650	23900	18750	19200	19900	18700
Trading	*Avg price*	*Avg price*	*Avg price*	*Avg price*	*Avg price*	*Avg price*	*Avg price*
Water	$0	$131	$200	$0	$0	$50	$79
Phosphorus	$0	$0	$0	$0	$160	$139	$70
Land Uses							
Dairy	4	4	3	3	3	3	3
Sheep/Beef	2	1	2	1	3	2	0
Arable	1	2	2	1	1	2	2
Forestry	0	0	0	2	0	0	2

Participant comments from Upper Waikato #1

Large corporate entities (pulp mill & hydro) prefer to deal with each other.

The District Council is charging too much for phosphorus, should take more of a 'public interest' position.

Farmers don't know how much water they're using. Lots of them are still there for the lifestyle, and want to have as little as possible to do with Fonterra, salespersons and the council [i.e. are not likely to be interested in trading water].

First in, best dressed means you need to get it quick or miss out [re constraint on upstream transfers].

Gets difficult to keep track of water, P and profits, having bought P allowance, is not clear if will get water/vice-versa, therefore, uncertainty in this scenario. … Bought water – can't get P, again, limiting factor. Need to buy P first, THEN water!

Easy to get confused.

The value of water declined substantially when P limits were introduced, from \$131 and \$200 in Rounds 2 and 4 to only \$50 and \$79 in Rounds 7 and 9. Participants needing both water and P units to intensify typically tried to acquire these as a bundle, and sellers sought to sell bundles rather than risk being left with unsold units and insufficient trading revenue to offset production changes. This attempt to trade in bundles made it more difficult to conclude transactions and made it less clear what the individual units were worth. Those who had to buy units separately sometimes found that hard:

> *Gets difficult to keep track of water, P and profits. Having bought P allowance, is not clear if will get water/vice-versa, therefore, uncertainty in this scenario.*

The restriction on upstream transfers created a rush to complete trades and hence a higher price (although it could have just as easily resulted in a lower price if the sellers had been more anxious to conclude a trade). A successful buyer was one who was quick at completing a trade, not necessarily one who had the most profitable use. As one put it:

> *'First in, best dressed' means you need to get it quick or miss out.*

Social networks also appeared to influence trading (albeit in an artificial environment). For example, participants managing the three dairy farms (all real-life dairy farmers who knew each other) tended to discuss possible trades with each other first. Māori participants were also approached quickly, with one of the dairy farmers observing that growing experience with iwi in various policy and industry settings had reduced barriers to approaching iwi, and that iwi were perceived as likely to be interested in mutually-beneficial trading opportunities. In some instances, offers to buy or sell from 'new' potential trading partners were declined because trades had already been ‘promised’ and/or relationships established that would be honoured even if a higher price was offered.

When a participant sold units for less than the marginal value indicated by their profit schedule, other properties designed to have gains from selling units could end up buying them, and then not consider the option of selling. Though this would need to be tested, it appeared that when evaluating options, participants tended to look first at how to increase profits by raising output, and only when this looked infeasible given the high cost of permits did they look at reducing output and selling permits. Thus, trading in this instance did not necessarily create the most efficient outcome because some permits sold for less than the true market value and were purchased by those who put them to sub-optimal use.

A whiteboard was made available for public posting of bids and was used intermittently, usually when there was little prior information about the value of allowances. Players generally found it easier to conclude trades without using the board, but they didn’t always get the best price. On the other hand, those who posted on the board found that they sometimes missed out because others made deals more quickly informally.

The Hydro operator found it difficult to know whether to buy water permits when there appeared to be an excess available, because unused water would remain in the river anyway. There was no ‘a priori’ profit-maximising strategy, and participants managing this enterprise in different workshops used a range of approaches. A strategy of not buying water backfired in one round when it appeared that water would go unused, but then a buyer appeared and paid more than it was worth to Hydro (who probably could have purchased it for less a few minutes earlier).

6. The second workshop: UW#2

6.1. Scenarios and outcomes from UW#2

The second Waikato workshop explored three issues: initial allocation criteria for nutrient discharges (existing use vs. ‘good practice’), the implications of water charges, and the potential for a would-be ‘water baron’ to buy up permits and use market power to raise permit prices. Participants were required to comply with water and phosphorus allocations in all rounds. Trading was also allowed in all rounds, subject to the same constraints on upstream transfer as applied in UW#1.

Based on economic theory, the first three rounds (testing allocation methods and water charges) were expected to produce results comparable to Round 7 in UW#1, assuming all possible gains from trade were realised. Charges were less than the market value of allowances and were thus expected to reduce the price of allowances but not adversely affect overall returns (where revenue from charges is treated as a transfer rather than a cost). For the scenarios testing market manipulation, we expected that allowance prices would rise in Round 5, adversely affecting overall returns, that the putative ‘water baron’ would benefit financially from secret information in Round 6, and that returns would fall in Round 7 as profitability of land uses fell. The simulation results are summarised in Table 2.

Table 2: Results from Upper Waikato #2. (Round 4 was skipped. Takes and discharges for the Lower River include those in the Upper River. Round 7 from UW#1 is included for comparison with Round 1.)

Results - Waikato #2	**W1:Rd7**	**Round 1**	**Round 2**	**Round 3**	**Round 5**	**Round 6**	**Round 7**
	Gains from trade	**Good practice allocation**	**Average allocation**	**Usage charges Water & P**	**Long Term Trades**	**Long Term Trades (2)**	**Long Term Trades (3)**
All rounds: Upstream limits. Trading of P & water. Rounds 5, 6 & 7 were connected (multi-round trades possible).	Workshop 1, Round 7. For comparison.	"Good practice" allocation of P.	Equal allocation of P & water.	"Good practice" allocation. Charges: water $4 & P $10.	Connected rounds. Speculator expecting price increase.	Speculator. Higher prices.	Speculator. Lower prices.
River Quality	*Upper River*	*Upper River*	*Upper River*	*Upper River*	*Upper River*	*Upper River*	*Upper River*
Total takes	7	2	2	2	2	3	2
P discharges	3.4	2.7	2.1	2.6	2.8	3.2	2.9
River condition	Good	Good	Excellent	Good	Good	Good	Good
	Lower River	*Lower River*	*Lower River*	*Lower River*	*Lower River*	*Lower River*	*Lower River*
Total takes	21	16	16	16	15	17	18
P discharges	8.4	8	7.5	8.4	8.4	8.3	8.5
River condition	Good	Good	Good	Good	Good	Good	Good
Financial outcomes							
Total profit: farming	14600	12600	12550	13742	13560	18280	11730
Non-farm net position	5300	5950	5750	6054	6660	6960	6560
Overall outcome	19900	18550	18300	19796	20220	25240	18290
Trading	*Avg price*	*Avg price*	*Avg price*	*Avg price*	*Avg price*	*Avg price*	*Avg price*
Water	$50	$83	$0	$50	$94	$94	$48
Phosphorus	$139	$195	$200	$190	$282	$249	$99
Land Uses							
Dairy	3	3	2	3	3	3	3
Sheep/Beef	2	2	3	2	3	3	3
Arable	2	1	1	1	1	1	1
Forestry	0	1	1	1	0	0	0

Round 1 involved allocations based on 'good practice' and was a replication of Round 7 of UW#1. Compared with UW#1, less development occurred in the upper zone (one property stayed in forestry) and, as a consequence, total profits were lower, contrary to expectations. This was due to a combination of factors, including unprofitable decisions by one or two players that pushed up demand for P and prevented the two forestry properties from converting to the extent they had in UW#1, and one lost a considerable sum. Less water was used, leading to higher profits for the hydro company, and the paper mill adopted a more profitable strategy, but this was not enough to offset the reduction in farming profit.

In Round 2, farm properties all received equal allocations of water and P, with total allocation equal to that in Round 1. This had marked effects on the profitability of different properties, as both forestry blocks converted to sheep and beef and the 'best practice' dairy farm intensified. However, the two standard-practice dairy farms with reduced allocations suffered, one converting to forestry even though he would have been better off changing to best practice. (By spending $200 to purchase one unit of P, he could have converted to best practice and still been $1,500 better off.) He also ended up with surplus water and P that he did not sell, suggesting that his actions were a protest against the policy of average allocation. During discussion, he said that imposing an abrupt change of this nature was unfair; farmers should be given time to adapt. On his comment sheet he wrote:

> *The P market has become polarised to one end; unable to buy or sell in upper catchment; run out of town by regulation.*

Although it should have been possible through trading to achieve the same or better overall financial outcomes as Round 1 (distributed differently due to the different initial allocation), total profits fell due to the dairy farm that converted to forestry. Had this player converted to 'best practice' dairy instead, total profits in the catchment would have been higher with average allocations than the 'good practice' allocation in Round 1 (although this was also depressed by unprofitable decisions). This is not entirely surprising since the profit schedules were such that the moderate-intensity levels were the most profitable given the market value of P and water permits. Given this, an average allocation means that most properties have an optimal or near-optimal allocation even without trading.

Round 3 reverted to the allocations of water and P used in Round 1 and introduced charges for water use and P discharges. Charges were 5% of the market price from the previous round, i.e. $4 per unit of water and $10 per 0.1 kg of P. (No water was traded in Round 2, so the Round 1 price was used.) Most participants said after the round that the low charges did not influence their decisions, and in fact the total profit was higher than Round 1 ($20,700 prior to charges, compared to $18,550). The dairy farm player who converted to forestry in Round 2 also protested about the charges in Round 3, saying the charges made it uneconomic for him to intensify. Discussion revealed, however, that even without the charges the market value of P was too high for him to justify buying any.

Rounds 5 through 7 were presented as an opportunity to explore long-term decisions under conditions of price uncertainty; in fact they also involved speculation and market power. Participants were able to make multi-round trades and were told that profitability of different enterprises was subject to changes in Rounds 6 and 7. The Forestry1 participant was secretly advised by the research team that prices were likely to rise by about 30% in the next round:

> *For these next few rounds, we would like you to act as a speculator and try to acquire permits in the first round, and to reap the benefits of this by selling permits (temporary or permanent trades) at a higher price in the next round (e.g. possibly hold some back to force up the price).*

Forestry1 was not told, however, that in Round 7 profitability would fall below the starting point. In Round 5, s/he only managed to buy 2 units of water and 0.2 kg P, and kept buying in

Rounds 6 and 7 to convert to dairy farming rather than selling permits to realise trading profits. This proved to be a disastrous strategy when prices dropped in Round 7.

6.2. Observations from Upper Waikato #2

Using an average allocation for water and nutrient allowances, as was done in Round 2, is clearly controversial as it, unfairly according to participants, creates winners and losers. From a purely financial perspective, because farm properties started closer to their optimal allocations, the average allocation would have generated higher overall returns if one dairy farm had not chosen a protest strategy. In real life, using an average allocation could have rather different consequences because of more variable profit schedules, sunk costs in existing investments, and the likelihood of imperfect markets for permits. For these reasons, in real life an average allocation is less likely to match the financially optimal allocation for a catchment.

The introduction of low-level charges did not reduce profitability and if anything might have improved it by motivating participants to sell units that were worth more to someone else. Even though the market value of units should have been sufficient to motivate profitable trades, it seems some were holding or buying units when they should have sold. It is also possible that participants were gaining experience after a few rounds, avoiding the poor decisions that were made in Round 1and identifying where the opportunities for gains lie.

Despite conditions conducive to market manipulation in Rounds 5 through 7, the would-be ‘water baron’ found it difficult to dominate the market. S/he commented that there wasn’t enough time to get round the room to buy up permits in Round 5, and then adopted a different strategy for the remaining rounds, which proved very costly. In a small catchment where trades are made informally and everyone knows everyone else, market manipulation of this nature (‘water barons’) appears unlikely, since one needs to have better information than others and be able to translate this into trading profits. In a large catchment, market manipulation is likely to be difficult for other reasons, namely the availability of many other possible sellers and the fact that future returns to water are uncertain (mainly due to fluctuating international commodity markets).

More generally, UW#2 provided further examples of the difficulty of making and implementing profit-maximising choices. In some cases this was simply due to mistakes in understanding and executing the available options, but in others it was due to poor price transparency and the difficulty of buying or selling bundles of water and P.

7. The third workshop: UW#3

7.1. Scenarios and outcomes from UW#3

The third workshop consisted of five connected rounds, each round notionally representing five years, in order to explore issues associated with transition to new policy measures. These measures included ‘penalty’ charges on nutrient losses as a transitional measure prior to both nitrogen and phosphorus losses being capped at ‘best practice’ levels. Revenue went ‘to fund the activities of the Waikato River Guardians' but this did not include mitigation measures, so river condition was still determined by nutrient losses and water use. The last round included an 'all-in' auction as a way to maximise market liquidity and encourage all permit holders to consider options for reducing nutrient losses.

The addition of a cap on nitrogen necessitated some changes to the profit schedules. We also took the opportunity to respond to participants' concerns that the schedules overstated the financial differences between standard dairy operations and best practice. We made the profitability of these two dairy options equivalent (rather than favouring standard practice) but retained a conversion cost for adopting best practice. Due to these changes, the financial results from UW#3 (see Table 3) are not directly comparable with financial results from the previous workshops.

Expectations were that financial performance would be stable in Rounds 1 and 2, decline in Round 3 when nutrient caps were imposed and improve in Round 4 as participants realised further opportunities for gains from trade. In theory and with perfect information, the auction in Round 5 would not alter the financial results except perhaps to make it easier for participants to identify opportunities to gain from trading. In practice, this outcome was uncertain given the novelty of the auction and the need for participants to manage multiple types of allowances.

As in the final rounds in UW#2, players were able to make long-term trades and the amount transferred upstream was capped. In addition, annualised conversion costs continued into subsequent rounds, meaning it would be costly to convert more than once because the conversion costs would accumulate.

Round 1 of UW#3 was 'business as usual' with water regulated but not nutrients. Participants were notified that both nitrogen (N) and phosphorus (P) would be capped in Round 3, and that in Round 2 there would be a penalty charge on N ($5/kg) and P ($25/.1kg) as an interim measure to encourage early reductions. This was charged only on nutrient losses that exceeded the 'best practice' allocations that each property would receive in Round 3, at which point all properties would be charged a low-level charge ($2/kgN and $10/.1kgP) on nutrient losses.

The lack of restrictions on nutrients enabled substantial profits to be made in Round 1, though this came at the expense of river quality as two properties converted to dairy farming. In Round 2, some properties responded to the penalty charges and adopted mitigation measures earlier than required, even though for some it would have been more profitable to wait until Round 3. Nutrient discharges declined, though not enough to improve river condition from 'Poor' to 'Fair'. Results are shown in Table 3.

Table 3: Results from Upper Waikato #3. (Takes and discharges for the Lower River include those in the Upper River. Farm and non-farm profit are after charges; 'Outcome w/o charges' shows total profits ignoring charges.)

Results - Waikato #3	**Round 1**	**Round 2**	**Round 3**	**Round 4**	**Round 5**
	Years 1-5: BAU	**Years 6-10: BP based charges**	**Years 11-15: Nutrient caps**	**Years 16-20: Nutrient caps**	**Years 21-25: Auction**
All rounds: Upstream limits. Trading allowed. All rounds connected (multi-round trades possible).	Water limits only. Notice of charges in Round 2; N & P limits in Round 3.	Charge on N & P loss in excess of "good practice".	Limits and low charges on N & P.	Repeat previous round.	"All-in" auction for N units.
River Quality	*Upper River*	*Upper River*	*Upper River*	*Upper River*	*Upper River*
Total takes	7	7	3	3	3
P discharges	4.7	4.3	2.5	2.4	3.1
N discharges	230	200	110	100	120
River condition	Poor	Poor	Good	Good	Good
	Lower River	*Lower River*	*Lower River*	*Lower River*	*Lower River*
Total takes	18	17	16	16	16
P discharges	7.6	7.4	6	6.1	5.7
N discharges	280	250	220	230	200
River condition	Poor	Poor	Good	Good	Good
Financial outcomes					
Total profit: farming	18850	16600	12110	13925	14475
Non-farm net position	6800	6725	5005	5065	4225
Overall outcome	25650	23325	17115	18990	18700
Charges	0	1475	1510	1510	1520
Outcome w/o charges	25650	24800	18625	20500	20220
Trading	*Avg price*	*Avg price*	*Avg price*	*Avg price*	*Avg price*
Water	$183	$183	$163	$85	$90
Phosphorus	$0	$0	$81	$76	$97
Nitrogen	$0	$0	$157	$181	$203
Land Uses					
Dairy	5	5	4	4	4
Sheep/Beef	1	1	1	1	2
Arable	1	1	1	1	1
Forestry	0	0	1	1	0

In Round 3, nutrient losses were capped at levels that ensured 'Good' river quality. With this came the challenge for participants to optimise across three inputs: water, N and P. Even with trading, it proved difficult for participants to secure the desired amount of these inputs and profits fell sharply. The price of water remained high even though nutrient allowances were now competing for scarce funds. Round 4 provided a chance for further trading and better realisation of the gains of trading. Profits increased and the price of water dropped as it became clear that nitrogen was the limiting input in the catchment.

Round 5 started with an 'all-in' uniform price auction for nitrogen allowances. Participants were required to put all of their N allowances up for sale and told they would get the revenue. This enabled them to buy back their allowances at no net cost. They were told to bid high (e.g. $1,000 per 10 kg N) for the number of units they considered they absolutely needed and a second, lower price for any units they might be willing to sell or additional units they might want to buy. This was challenging for participants, including members of the research team who were managing properties in the simulation, since P and water allowances had to be transacted after the auction and hence management strategies involved uncertainty.

The auction cleared at $200 per 10 kg N. One participant (Dairy1) didn't understand the auction and failed to obtain any units, creating pressure to obtain N in the secondary market. Meanwhile, Forestry2 went into the auction with no allowances, bought five 10-kg units and resold two at $200. Other units sold for between $150 and $200 but, when the round was about to close and Dairy1 still needed N, Forestry1 sold him one unit for $500.

Market prices for units of water, N and P are shown in Figure 2.

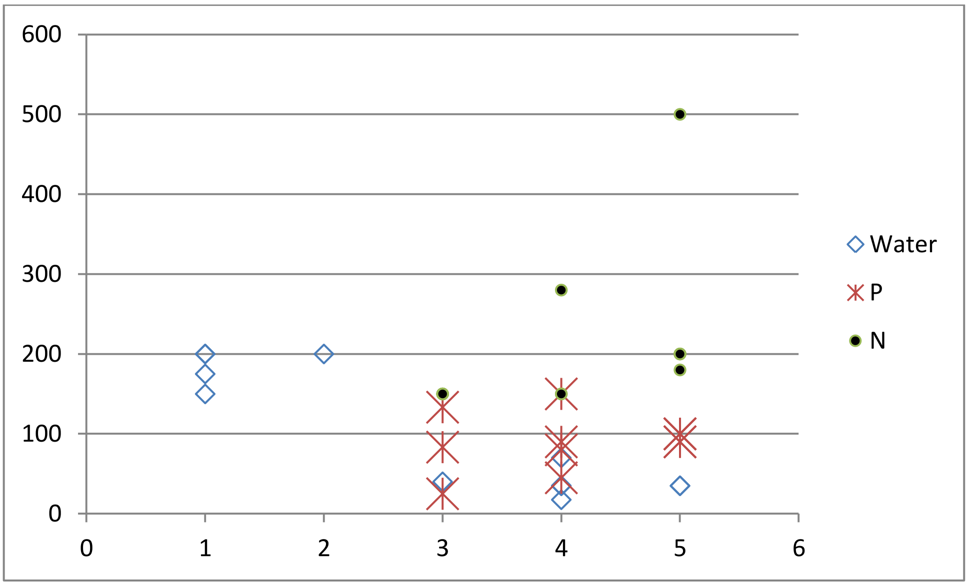

Figure 2. Prices ($ per unit) from bilateral transactions for water, phosphorus and nitrogen permits in Upper Waikato #3. Round 5 prices do not include the auction for nitrogen permits.

7.2. Observations from Upper Waikato #3

A dairy farm participant commented that the charges had a strong incentive effect when they were a 'penalty' for exceeding a certain level (Round 2). Once they applied to all discharges (Round 3), this participant said he no longer factored them into decisions. Another participant commented that he tends to focus on factors that are highlighted by the decision tools available. These comments suggest that MBI settings can have a signalling effect beyond the direct financial incentive. A charge that selectively targets high discharges implies that these are socially unacceptable and should be reduced. This, and perhaps a desire to get ahead of regulatory changes, resulted in some properties reducing their nutrient discharges a round earlier than strictly necessary (however, another property converted to dairy early to make money while s/he could and then went back to forestry when nutrient limits were imposed). These could be simply different responses to perceived risks rather than a perception of “social unacceptability”, although because the latter can influence policy the two are not unrelated. More in-depth research would be required to understand better these influences on behaviour.

In a related comment, a participant said that it is not socially acceptable to have high discharges from one property even if it is legally compliant and within a total cap, because environmentalists will be ‘looking over the fence’ and pointing fingers. The research team explained that in real life, local limits might still be needed to protect local streams etc. in addition to an overall limit for a catchment. This was reflected in the simulation by having two zones, each with its own limit and constraints on transfers between the two. It is important that the relevant limits have been identified and are in place. An example was cited from Lake Taupo, where one dairy farmer has intensified by purchasing nitrogen allowances. Is the council satisfied that this will not cause unacceptable local effects?

A common observation from several workshops was that participants tended to fix on a strategy and then stay with it, which led to some missed opportunities. For example, most farm properties sought to increase production and therefore wanted to buy allowances. They tended not to think about whether they could make more money by reducing output and selling allowances. The district council and pulp mill, on the other hand, tended to focus on funding mitigation measures by selling allowances but in some cases should have been trying to buy units from farmers to avoid costly mitigation measures.

As some participants noted, it is difficult to identify a viable strategy when the market value of units is unclear, as is the case with new markets and markets subject to volatility. The value of allowances might take a few years to become clear and some water users will be slow to focus on the implications of MBIs for their operations.

So while MBIs are likely to lead to more efficient use of water and nutrient capacity, this might happen gradually rather than quickly. And, Round 5, when Dairy1 failed to obtain N units in the auction, showed that if water users don’t understand new policy developments and are slow to respond (or too quick, if actions are not well considered), it can prove costly to them.

Finally, some participants raised the prospect of a ‘cooperative agency’ to purchase nutrient units on behalf of farmers. This would protect milk supply to the factory, could counter any market dominance by would-be water barons, and could also help to ensure environmental goals are met, e.g. by limiting how many any one farmer gets. There is some precedence for this with fisheries quota: fish processing companies purchased quota from inshore fishermen in part to protect company investments in processing capacity (Sinner & Fenemor 2005). The processing sector was not cooperatively owned, however, and this development was not seen favourably by many fishers, who had to lease catching rights from the processing companies.

Participant comments from Upper Waikato #3

Trying to meet multiple objectives is very complex. Farmers will need to have profit optimisation tools.

Lots of effort needed to find optimum, but I want to focus on my CORE business.

Blind auction is difficult – easier to talk to other bidders.

Water is cheap – Nutrients cost! Easier with incremental changes but only if you know likely policy changes ahead.

8. Actual vs 'optimal' results

We used linear programming software5 to find the maximum possible financial returns for the scenarios and compared these with the results achieved in the simulations. In Figure 3, the blue bar represents the maximum financial returns available if allowances are not transferable between properties. The optimal returns, shown in green, assumed that water and discharges were freely transferable and hence could be used for the highest financial return, whereas in the simulations this was constrained in some cases by the non-tradeability of units and, where units were tradeable, by participants not making the financially optimal trades (assuming participants were seeking to do this). The red bar shows the amount by which trading enabled gains over the "no trading" benchmark. Results thus need to be interpreted in context of the constraints imposed each round and whether trading was available (e.g. scenarios 11 and 15 had no trading).

In the simulations, trading improved financial performance and, in general, participants managed to get close to optimal results when only water was constrained, and it was tradeable. Adding nutrient constraints lowered the maximum returns possible and made it noticeably more difficult to realise profit-maximising transactions. That said, performance tended to improve over time and the returns with three constraints in UW#3 were similar to returns with two constraints in UW#2 (although changes to profit schedules for UW#3 mean that the results are not directly comparable).

[5] See www.ampl.com and Fourer et al. (2002).

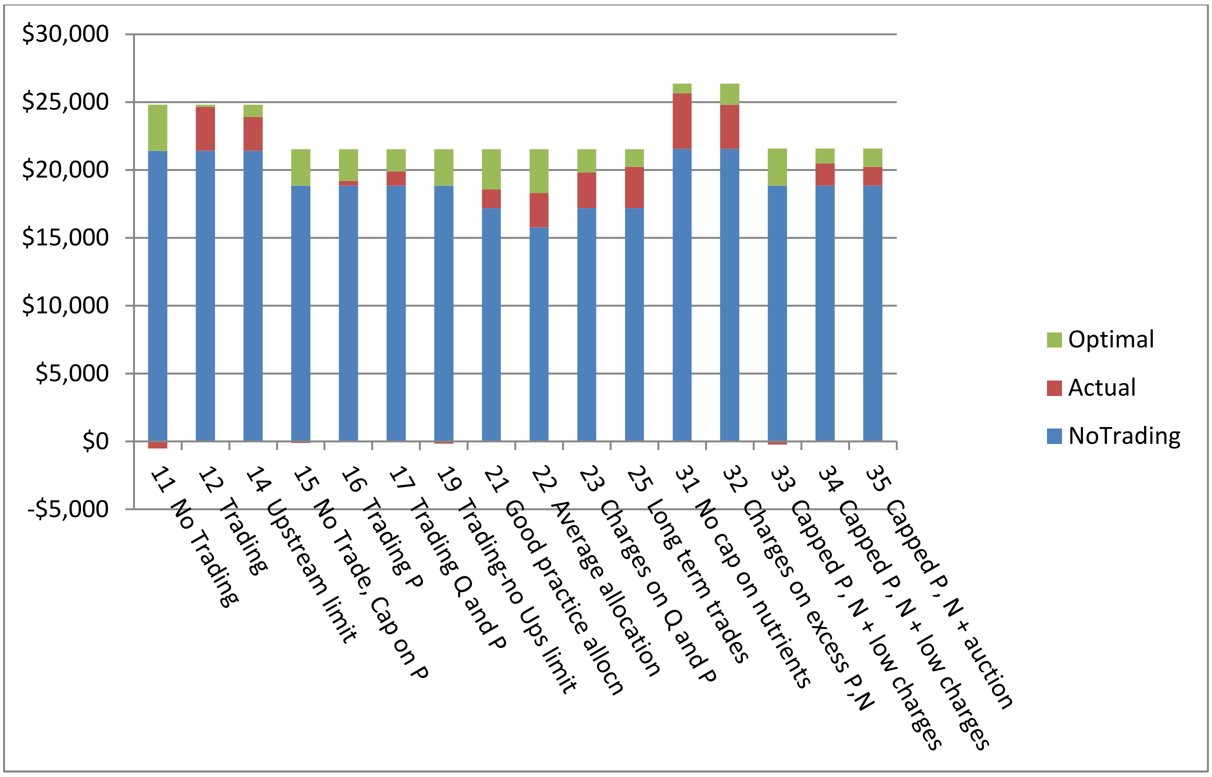

Figure 3. Optimal versus actual financial results from Waikato simulations (scenario labels on horizontal axis: first digit is workshop number, second digit is round number, e.g. 16 is workshop 1, round 6). Due to changes in profit schedules, results from UW#3 are not directly comparable to results from UW#1 and UW#2.

9. Discussion

9.1. Is the environment protected?

MBIs are best suited for improving the economic efficiency of freshwater management, for which there are also environmental and socio-cultural objectives. Environmental objectives will be met largely by regional councils establishing and enforcing clear limits for both water quality and quantity under the RMA. These requirements exist whether MBIs or purely administrative approaches are employed. As seen in the simulations, environmental objectives can be achieved by setting and enforcing a cap on water use and discharges. However, MBIs can influence the achievement of environmental objectives in the following ways.

Firstly, increased transferability of water permits can result in increased use if so-called 'sleeper permits' are transferred and activated. This can cause water quality and/or flows and levels to decline, as occurred in Rounds 2 and 3 of the UW#1 simulation. Increased use is not necessarily a problem if the total amount allocated is consistent with the community's water quality and quantity objectives.

Secondly, if not anticipated and addressed in policy design, transfers of permits can result in use being concentrated in small areas (‘hot spots’), perhaps with unacceptable environmental effects. This can be addressed by regional plan rules that define the zones within which permits can be transferred and that set limits for each zone. This was demonstrated in the Waikato simulations for this project, where separate upstream limits protected river condition in the upstream zone. This reinforces the point that it is the setting of environmental limits, including for specific parts of a catchment where necessary, that is the main determinant of whether environmental objectives are met. If a water take or discharge has the potential, by itself, to cause unacceptable effects on a water body or another user, these effects should be controlled through conditions of use on that site. That is, they would be part of a site or use consent rather than part of the water entitlement or discharge allowance (Sinner and Fenemor, 2007).

Thirdly, water use charges or discharge fees can be used when necessary as a complement to limits to raise revenue for environmental mitigation, e.g. for historical (‘legacy’) impacts, while limits address current pressures. This approach was demonstrated in both the Hawke’s Bay and Waikato simulations. (Charges could be used as a primary instrument for pursuing environmental objectives, but that option provides less assurance that environmental objectives will be achieved, and was not pursued in this study.)

9.2. Efficiency

The Waikato simulations included the ability for a hydro company to trade a portion of its flow allowance with farmers and other abstractive users. This was reasonably straightforward within the simplified catchment used, and participants commented that the presence of a ready buyer and seller of water permits made it much easier to adjust land use in response to nutrient caps. That is, farming participants could focus on obtaining (or selling) the necessary nutrient allowances, aware that water could be bought or sold for a known price. In practice, existing consents for hydroelectric facilities might need to be amended to specify conditions that allow for trading while ensuring that releases provide for ecological requirements and downstream interests.

9.3. Roles of Information, Brokerage and Facilitation

Provision of simple systems to facilitate transfers of water allocations received support from participants. Action could be prioritised on facilitating temporary transfers (e.g. leases), and with limited additional work could also facilitate permanent transfers. One important design element is Permitted Activity rules to allow exchanges of water among users within a management zone, subject to notification of the transfer to the council. The water use or discharge activity itself would still require a resource consent, to ensure appropriate monitoring and reporting, but transfers could be permitted subject to notification. We recommend investigation of how a simple web-based system could facilitate this process.

Greenhalgh and Selman (2011), based on an international review, noted a large variation in the market mechanisms used in water quality trading programmes and a shift over time away from bilateral trading to exchanges and third-party brokers or pools. They attributed this to the high transaction costs of early trading programmes and the desire to simplify and streamline the process. This could be achieved, they suggested, by the development of standardised regulatory documents (i.e. plan provisions and consents), 'model' contracts for sale and purchase, and mechanisms to facilitate trades and approve them quickly. These are useful observations for facilitating MBI implementation in New Zealand also.

In the Waikato and Hawke's Bay simulations, participants seemed to prefer bilateral negotiation and transactions and some found the process of bidding into a centralised market rather confusing. Nonetheless, we consider that this is primarily a matter of users learning how these markets work. One of the benefits of a centralised market is that it reveals prices across all participants, rather than from just independent bilateral agreements. Bilateral trading can still be available for those who prefer this, and even these users will benefit from the price discovery provided by a central market mechanism, especially where there is limited experience and hence poorly informed expectations about starting market prices. Sinner and Crengle (2006) found that participants, with some coaching, learned within a few rounds how to formulate bids to a uniform price market.

9.4. Charges to Promote Efficient Use of Water

We also explored charges as a complement to transferability, mostly as a mechanism to raise revenue for mitigation but also to provide another signal for efficient resource use. In theory, the value of an allowance as revealed by trading is sufficient to motivate scrutiny of resource use, but in reality farmers and others have many things to focus on and the opportunity cost of water allowances might not be top of the list.

A charge on water use or nutrient discharges might help to increase attention to the opportunity cost of allowances. As was seen in the UW#3 simulation, a penalty charge for 'excessive' nutrient loss got users' attention because it was seen by some participants as a sign of community disapproval.

Charges could also be an efficient way to achieve environmental objectives. This could apply in over-allocated catchments in which allocations are being reduced gradually over time, or where some mitigation actions are most efficiently funded and coordinated centrally rather than at a property level. Charging activities that cause adverse effects, such as water use and discharges, is economically more efficient than taxing personal or company income.

When combined with transferability, charges are unlikely to detract from long-run efficiency if set below the market value of allowances (i.e. the value of allowances in the absence of charges). There could be a problem in the short term if charges put pressure on producers' balance sheets, e.g. if a user has a marginal operation and has borrowed assuming there would be no charges for using water. This suggests that charges of this magnitude should be announced well in advance or phased in over time.

Charges can be applied either to the amount of water used (or nutrients discharged) or to the amount of allowances held. A user incurs some opportunity cost in holding unused units, and the environment does benefit from unused permits, so it is probably preferable to charge for allowances used rather than held.

9.5. Social and Cultural Objectives

MBIs will affect social and cultural relationships with fresh water. For example, if transfers do not require approval from the regional council, iwi and hapū will not have the opportunity to make submissions on those transfers and they will find it harder to maintain an overview of how and by whom water is being used. To reflect tangata whenua values and interests, therefore, it is important to ensure that iwi and hapū are actively involved in drafting and potentially in implementing the relevant plan provisions.

MBIs, whether transferable permits or water use charges, can have implications for the distribution of wealth, from little change to potentially significant redistribution. This is most often experienced as a debate over initial allocations of water permits or discharge allowances but can also arise with charges. Initial allocation based on existing use ('grandparenting') protects the wealth of existing users but can, especially where new units are being created (e.g. allowances for a nutrient limit), also have a negative impact on development opportunities and hence asset values of owners of undeveloped land. Expectations of grandparenting can also encourage uneconomic intensification (i.e. that is financially viable only if there is no cost for nutrient discharges) that is expensive to address.

Conversely, allocations based on land capability or another averaging approach (assuming that some existing users will be allocated insufficient allowances to maintain current production) protect the opportunities of those with undeveloped land but at the expense of existing users, creating potential issues with stranded capital assets. And because land capability and 'best practice' will vary by property in ways impossible to reflect in allocation rules, some landholders are likely to be unfairly penalised by these approaches.

This dilemma is not unique to MBIs, however. Any policy that involves an environmental limit, as required by the NPS, will also require a decision about how that limit will be shared across landowners and users and some will have their economic opportunities constrained. Transferable permits at least provide a mechanism for users who are short of allowances to obtain more. These issues were only touched on briefly in this project, but in the UW#2 simulation, for instance, one of the farmer participants protested about the financial impact of average allocations and charges. Transitional policies, discussed further below, offer one means of addressing such concerns.

MBIs, and more generally policies to assign economic values to ecosystem goods and services, are also sometimes seen as representing the commodification of water, bringing water more firmly into the capitalist economy and undermining more spiritual or holistic relationships with water bodies (Robertson, 2012). This may be unavoidable given the vital role that water plays in modern economies, the current pressures on freshwater systems and aspirations for further economic development. It is also no different to the situation for land, for which similar cultural and spiritual relationships exist, yet which is allocated through a market system. Putting an explicit value on water use and nutrient discharge will discourage wasteful practices and incentivise more efficient use and makes more transparent the economic consequences of social and cultural uses of water.

Cultural norms and institutions that emerged under conditions of abundant clean and clear water are unlikely to be able to manage the current level of abstraction and discharges, let alone meet future aspirations. We note, however, that the Crown and iwi are engaged in conversations about new institutions, such as the co-governance arrangements for the Waikato River, that might be able to provide for cultural values while also being flexible enough to cope with modern pressures and demands on freshwater systems.

Water use charges or discharge fees are one example of a new arrangement that could be used to further these goals. Revenue from charges can be used to address socio-cultural issues such as hapū or in-stream users who have been adversely affected by discharges and abstractions (Sinner and Scherzer, 2007). Giving iwi or other civil society groups a role in deciding how such revenue is to be used could help to restore traditional relationships with fresh water in a way that goes beyond the transactional focus of MBIs.

A further example is the opportunity for iwi to collaborate in water user groups that develop collective strategies for meeting water quality objectives, and maintaining environmental flow regimes as an alternative or complement to more formal transfers or trading. They may also wish to participate in water sharing or rostering discussions, to be assured that environmental objectives are being met.

10. Conclusions

The simulations provided an opportunity for stakeholders to experience a number of different policy scenarios for tradable allowances and charges for water abstraction and nutrient discharge. Given the limited number of participants and replications and the simplified catchment and profit schedules, the results should not be seen as predictions of what would happen under these market-based instruments except in a very general sense. Rather, the simulations provided a platform for discussion and consideration of questions such as what might lead to different outcomes in real life, what concerns stakeholders have, and how such policies could be improved to make them more acceptable. Participants also said that the simulations were a valuable learning experience for them.

In general terms, the ability to transfer or trade water or discharge allowances relatively freely (i.e. with low transaction costs and no need to seek regulatory approval) enabled users to increase the total financial returns across the catchment while meeting environmental objectives. This provides flexibility for new entrants and new uses of water, addressing the re-allocation issue, and helps to mitigate the financial impact of setting and enforcing new limits that are below existing use levels. Participants generally supported making water permits and discharge allowances more easily transferable. There were concerns, however, about the possibility of “water barons” and Maori respondents wanted to see ownership issues resolved.

When only water abstractions were limited, and permits were tradable, participants managed to realise most of the potential gains from trade. This was noticeably more difficult when a nutrient constraint was added and even more so when a second nutrient was constrained. In these latter cases, participants often had to negotiate two or more transactions to buy or sell the desired amount of allowances to enable their intended land use change. After one or two rounds of multiple constraints, however, they learned who was interested in buying and selling and the prevailing prices for different kinds of allowances, and financial returns improved.

It was also evident that, even in a small room with only ten participants, social networks influenced trading. Participants preferred bilateral transactions and some found the process of bidding into a centralised market confusing. Nonetheless, we consider that this is primarily a matter of users gaining confidence in market mechanisms.

Trading within one's social network can contribute to inefficient outcomes when permits sell for less than the true market value and are purchased by those who put them to sub-optimal use. One of the benefits of a centralised market is that it reveals prices across all participants, rather than from just independent bilateral agreements. Bilateral trading can still be available for those who prefer this, and even these users will benefit from the price discovery provided by a central market mechanism, especially where there is limited experience and hence poorly informed expectations about starting market prices.

Other social considerations also influenced simulation outcomes in that participants did not always seek to maximise financial returns. In some cases, participants chose not to intensify, or to de-intensify, for what might be termed "lifestyle" reasons. These choices are not necessarily economically inefficient, because people making such choices might put a higher value on the lifestyle choice than on the financial return available through other options.

Charges on water use or discharge allowances are compatible with 'cap and trade' policies. The reasons for applying charges are mostly to do with sharing of the costs and benefits of limited access to water and discharges, e.g. providing a return to the community and addressing concerns about windfall gains from access to public resources. There are also circumstances in which charges might be used in conjunction with cap and trade to promote more economically efficient outcomes, e.g. where mitigation can be achieved at less expense collectively than on individual properties.

Market-based instruments can be expected to increase the financial returns from land and water use within environmental limits. The extent and pace of that improvement is likely to vary by catchment, and to increase over time as stakeholders become more familiar with new policy settings and as the value of water allowances becomes clearer. Central and local government can facilitate this process by offering learning opportunities, encouraging brokerage services and providing centralised mechanisms for buying and selling of allowances.

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Appendix

The Upper Waikato simulations included the following entities:

Upstream catchment (Lake 1)	
Dairy 2	A ‘standard practice’ dairy farm, this property started with 1 surplus unit of water and relatively high nutrient losses. Farm has option of converting to ‘best practice’ to reduce nutrient runoff.
Sheep & Beef	A ‘long established’ sheep and beef farm, this property has excellent potential for conversion to dairy or arable farming, but started with no water permits and low nutrient discharges.
Forestry 1	A recently harvested forestry block with potential to convert to best-practice dairy or to sheep and beef.
Forestry 2	A recently harvested forestry block with potential to convert to best-practice dairy or to sheep and beef.
Downstream catchment (Lake 2)	
Dairy 1	A recently established farm using best practice, this property started with a limited water allocation and hence low intensity.
Dairy 3	A ‘standard practice’ dairy farm with relatively high nutrient losses; converting to ‘best practice’ would reduce these.
Arable	A productive operation with the potential to reduce relatively high nutrient losses. Conversion to dairy also possible.
District Council	Council has options to reduce water use and nutrient discharges, but these would require some investment and the council is trying to keep rates down.
Pulp Mill	The mill has some investment options that would reduce its nutrient discharges, or it can reduce output.
Hydro company	The hydro company makes a profit from water going through its turbines and could purchase additional units. It started with 5 units of water that it could sell to other users.
River Trust	The second workshop had a trust that received revenue from water charges and invested this in measures to improve river condition. This was done by the simulation manager rather than being a separate role in the scenarios.